

The CFHT Legacy Survey

Operations and Services at CFHT

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CFHTLS National Meeting - France - IAP/Terapix - Feb. 04, 2005



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SCIENTIFIQUE



The MegaPrime Project

The components



- ✓ *Upper end (CFHT / INSU) – Thermally Regulated*
- ✓ *Wide-field Corrector (HIA / SAGEM-REOSC) – 4 lenses*
- ✓ *Image stabilizing unit (Obs. de Paris) – Tip-tilt correction up to 5Hz*
- ✓ *Focus-guiding unit (HIA / CFHT) – 2 guiders & autofocus*
- ✓ *MegaCam (CEA) – 40 CCDs mosaic*

The specifications

- ✓ *1 full square degree field of view*
- ✓ *Properly samples 0.7 arcsec. seeing*
- ✓ *Sensitive from the u to z band (Sloan filters)*
- ✓ *Image quality: 0.1 arcsec from center to edge*
- ✓ *Low overheads (detector limited)*
- ✓ *Operated within CFHT's New Observing Process (QSO + Elixir + DADS)*



MegaPrime & MegaCam first 2 years

- ✓ *Complex instrument*
- ✓ *High usage: 55% of the telescope time*
- ✓ *Sensitive operational load: requires preventive maintenance*
- ✓ *Still some on-going development & tuning (image quality & autofocus)*
- ✓ *Despite difficulties, MegaPrime has had only a few nights of down time*

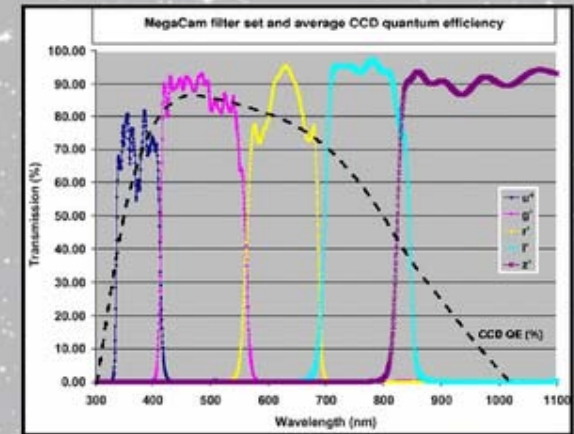
Time range	QSO run(s)	Event	Effect on data
02 Dec. 04 - present	04BQ05 and on	L3 lens flipped upside down	Spectacular IQ improvement
01 Nov. - 04 Nov. 04	04BQ04	L3 lens flipped upside down	Spectacular IQ improvement
08 Sep. - 22 Oct. 04	04BQ02-Q03	Defective video board	MAXLINB=32K right amp CCD27->35
05 Sep. - 07 Sep. 04	04BQ02	Defective video board	Half mosaic not operational (18-35)
14 Aug. - 24 Aug. 04	04BQ01	CCDs 00,11 defective	Only A amplifier (left) off for 07 and 11
06 Aug. - 14 Aug. 04	04BQ01	CCDs 00,07,09,10,11 defective	Only A amplifier (left) off for 00 and 11
16 Aug. - 17 Aug. 04	04BQ01	Ice on window dusk to 1 AM	Large blob obstructing light
06 Aug. - 07 Aug. 04	04BQ01	Ice on window all night	Large blob obstructing light
06 Aug. - 10 Aug. 04	04BQ01	Vacuum gauge glow	Large structures in all bands
07 Jul. 04 - present	04AQ07 and on	L1 cell O-ring removal	No obvious IQ improvement
25 Feb. 04 - present	04AQ01 and on	Light baffle installed	Cut stray lights, lower sky background
13 Jan. - 30 Jan. 03	03BQ07	CCD03 non operational	2.7% off the field of view at the edge
16 Dec. - 31 Dec. 03	03BQ06	CCD03 non operational	2.7% off the field of view at the edge
28 Nov. - 03 Dec. 03	03BQ05	CCD03 non operational	2.7% off the field of view at the edge
27 Oct. - 01 Nov. 03	03BQ04	CCD03 non operational	2.7% off the field of view at the edge
22 Oct. - 22 Oct. 03	03BQ04	Ice on window 3 AM to dawn	Large blob obstructing light
18 Sep. - 04 Oct. 03	03BQ03	CCD03 non operational	2.7% off the field of view at the edge
18 Jul. 03 - present	03AQ06-present	WFC original tilt & centering with 5.5mm spacer	Back to best optical setup
16 Jun. - 17 Jul. 03	03AQ05	WFC 0.02 deg. tilt to west side with 5.5mm spacer	Not optimal optical setup yet

MegaPrime+ MegaCam Performance

- ✓ *350 million pixels (~18000x18000) – 700 Mb per image*
- ✓ *Geometry: 0.96 x 0.94 sq. degree*
- ✓ *Sampling: 0.187 arcsec/pixel*
- ✓ *Improved image quality: only 2 corner CCDs with poor IQ*
- ✓ *Excellent immunity to scattered light*
- ✓ *Photometric performance:*



Filter	u*	g'	r'	i'	z'
SNR=10 – 0.8 arcsec seeing – 1hr integration :					
Point source – Dark	25.5	26.1	25.6	24.9	23.9
Point source – Grey	25.2	25.7	25.3	24.9	23.9
Field galaxy – Dark	24.9	25.5	24.9	24.2	23.3
Field galaxy – Grey	24.5	25.0	24.6	24.2	23.3



✓ *LS-Deep mean image quality*

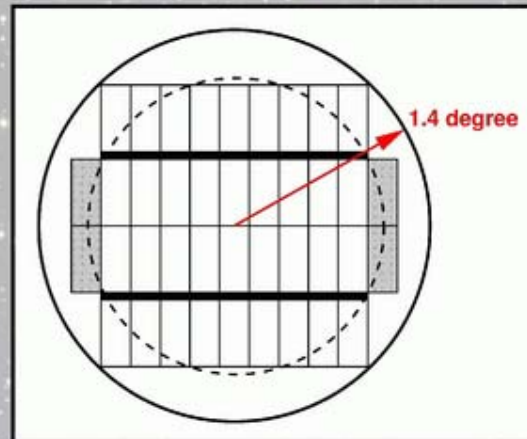
u* = 0.89 arcsec.

g' = 0.89 arcsec.

r' = 0.84 arcsec.

i' = 0.80 arcsec.

z' = 0.76 arcsec.

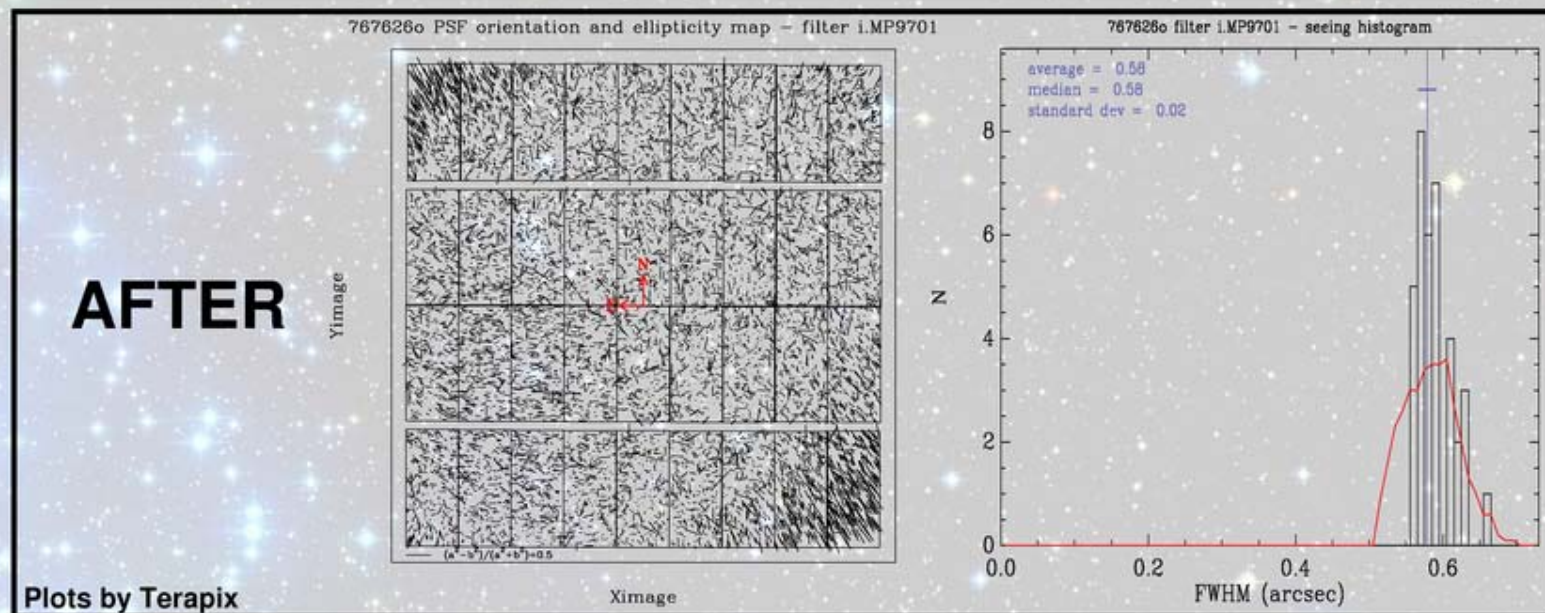
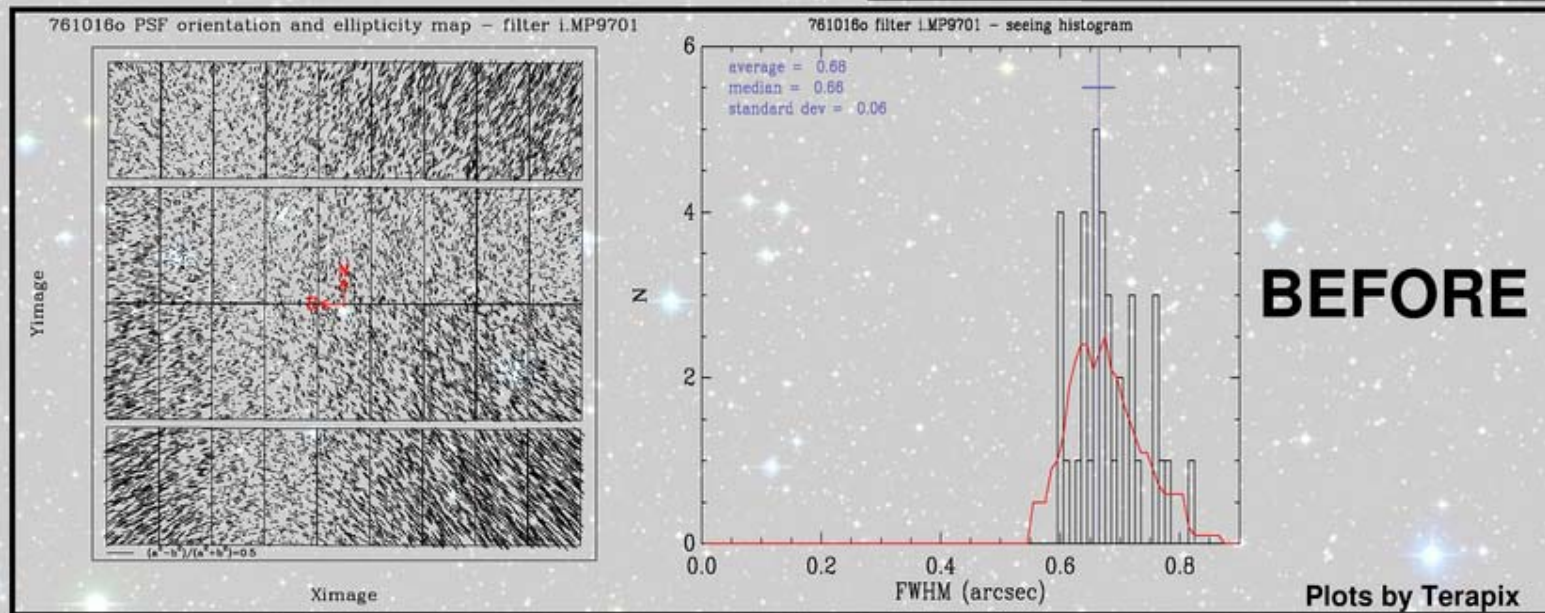


Dramatic IQ improvement

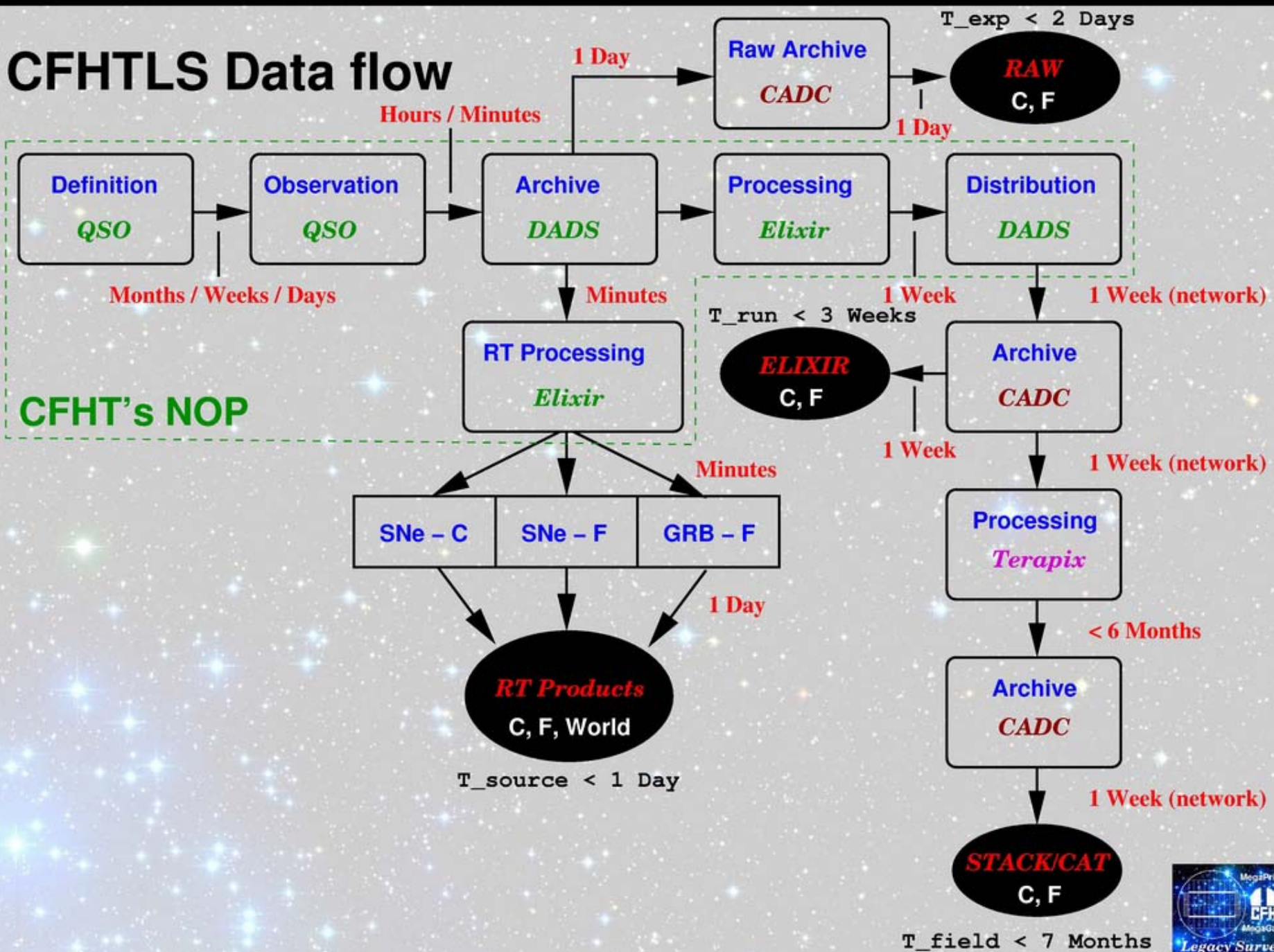
The flipped L3 configuration



10.5410.4910.4810.4910.4710.4610.4610.4910.541
10.4910.5010.4910.4710.4610.4610.4510.4410.451
10.5110.5310.5410.5010.4710.4710.4610.4610.491
10.5310.5410.5410.5310.5010.4810.4810.5410.651



CFHTLS Data flow



Services: entities serving the CFHT Legacy Survey community

CFHT

Gather, Detrend & Calibrate

- ✓ Get the raw data (QSO)
- ✓ Detrend the data (Elixir)
- ✓ Calibrate the data (Elixir)
- ✓ Collect the Meta-Data (DADS)
- ✓ Ship data to CADM (DADS)
- ✓ Quality control
- ✓ Progress report

Terapix

Calibrate, Stack & Extract

- ✓ Science images:
 - Fully calibrated
 - Stacked
- ✓ Source catalogs
- ✓ Quality control
- ✓ PI service

CADC

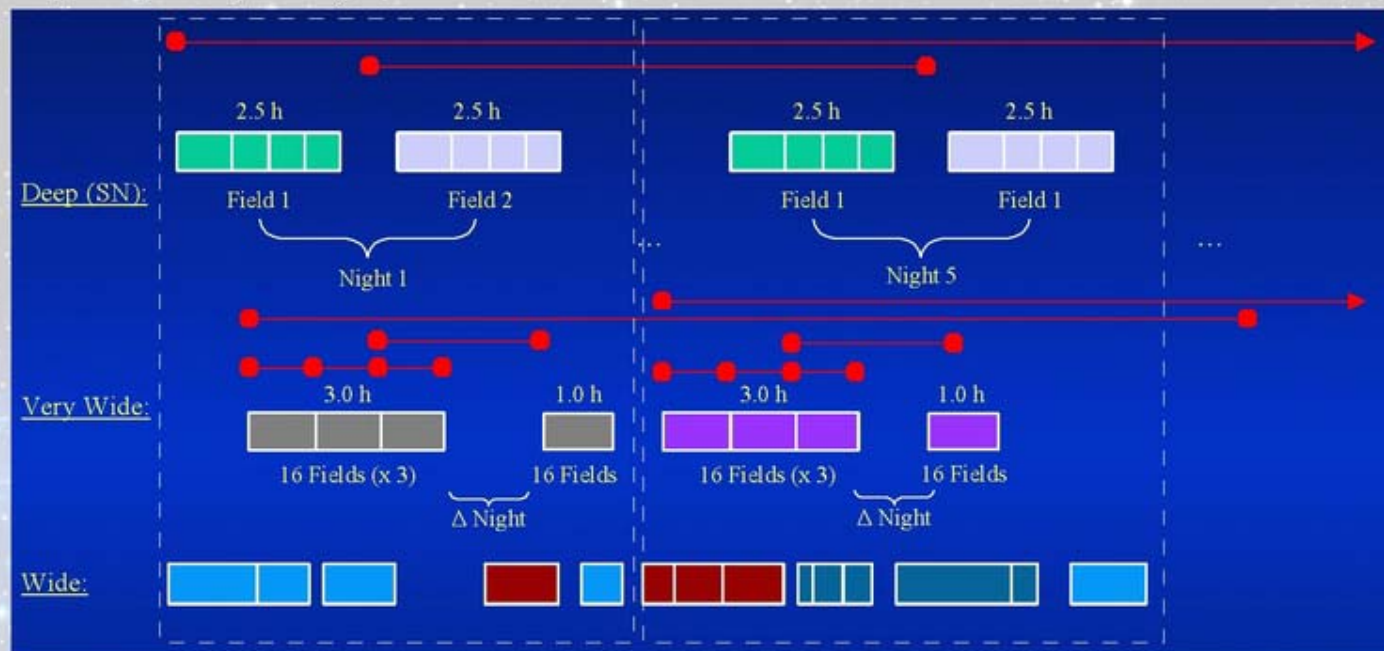
Archive & Distribute

- ✓ Raw MegaCam FITS data
- ✓ CFHT data products
- ✓ Terapix data products

The CFHTLS seen by the Queued Service Observing (QSO)

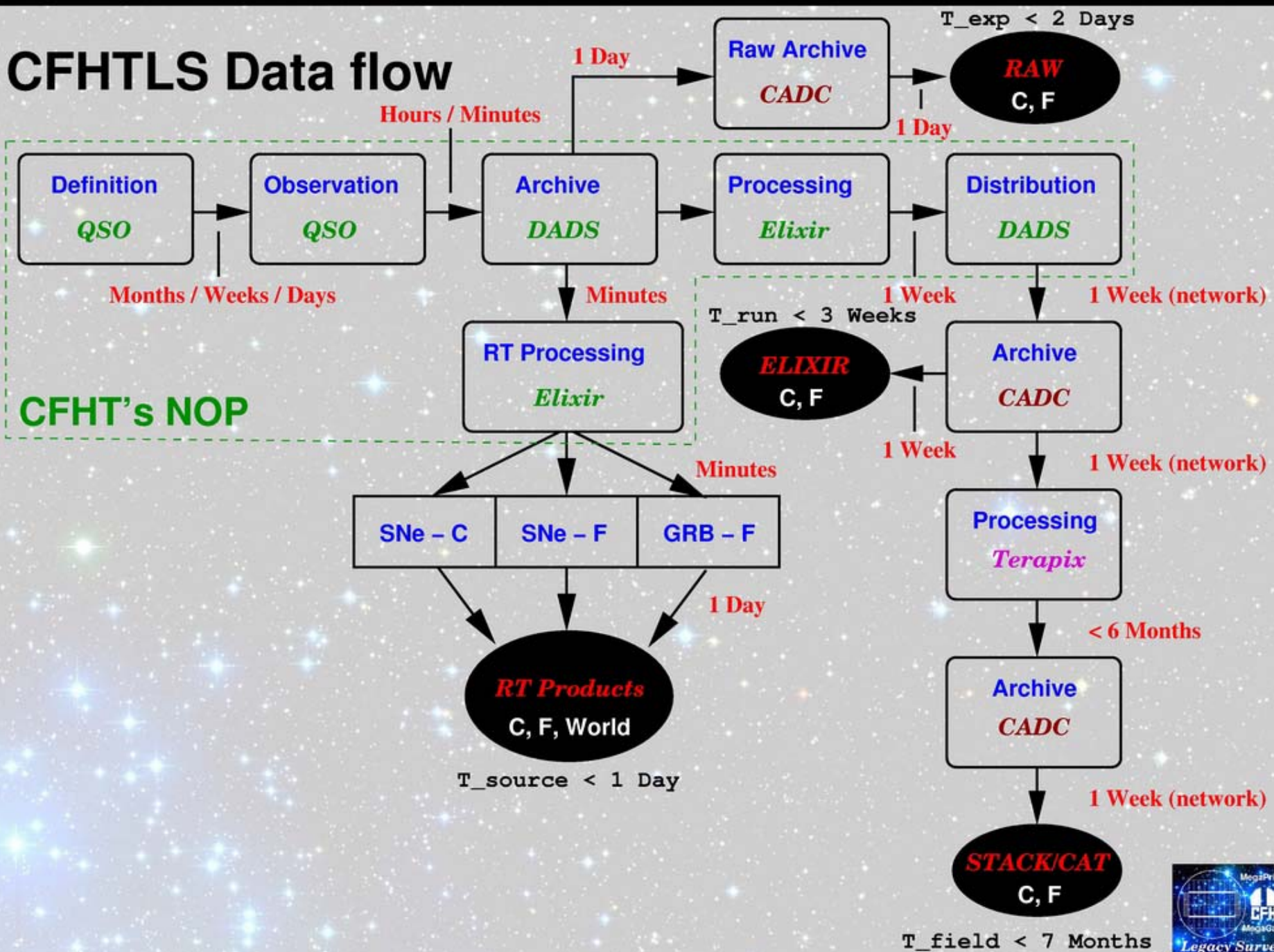
A complex endeavor:

- ✓ *Time critical observations on a large-scale:*
 - SNe fields every 4 nights, 2 fields per run*
 - Each Very Wide patch has 5 time constraints*
- ✓ *Balancing Agency Time (access time not equal to guaranteed time!)*
 - PI programs (50%) versus CFHTLS (50% or "49" nights at best per semester)*
- ✓ *Balancing time share between CFHTLS programs*
 - Deep (44%), Wide (34%), Very Wide (22%)*
- ✓ *Example of conflicts just with the CFHTLS:*



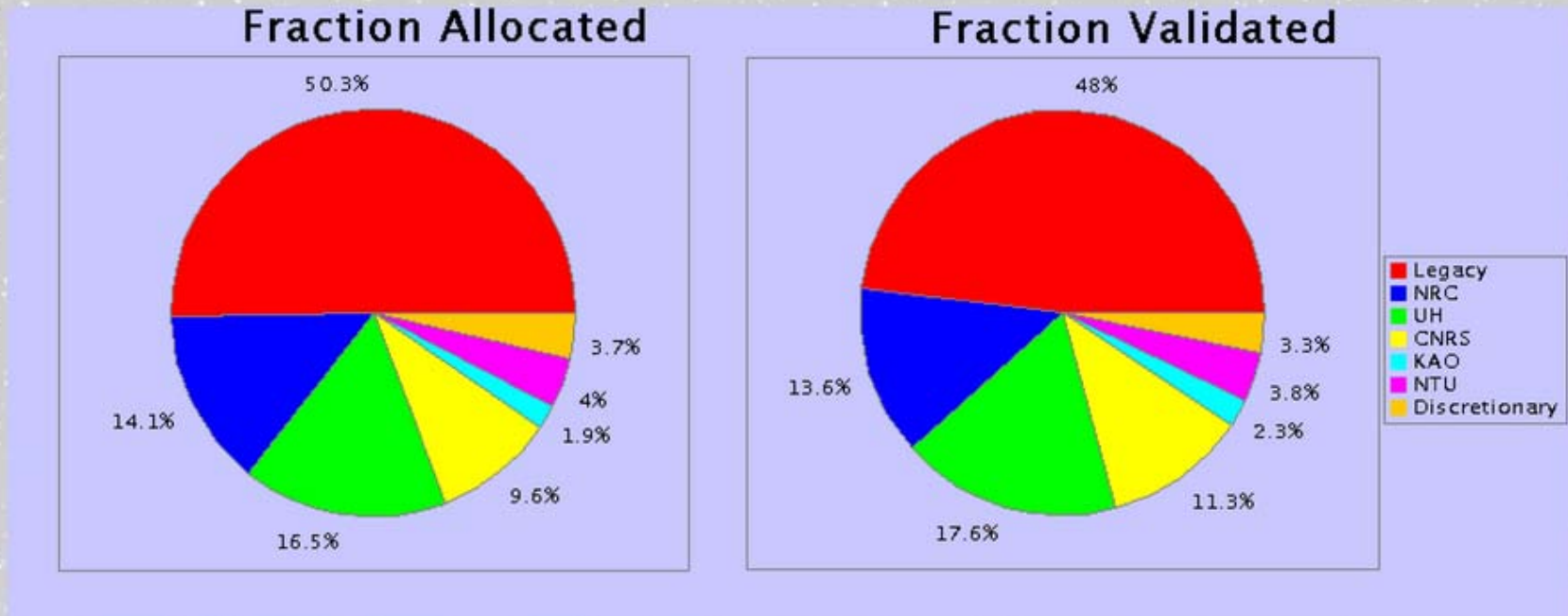
- ✓ *Time constraints are a real challenge, require planning, understanding of programs and priorities, and constant attention to the general balance.*

CFHTLS Data flow



Balancing the agencies and the CFHTLS components

✓ *Agencies balancing (TOP priority): (for semester 04B)*



✓ *CFHTLS balancing: (as of Feb. 2005)*

Requested: Deep/SNe = 44%, Wide = 34%, Very Wide = 22%

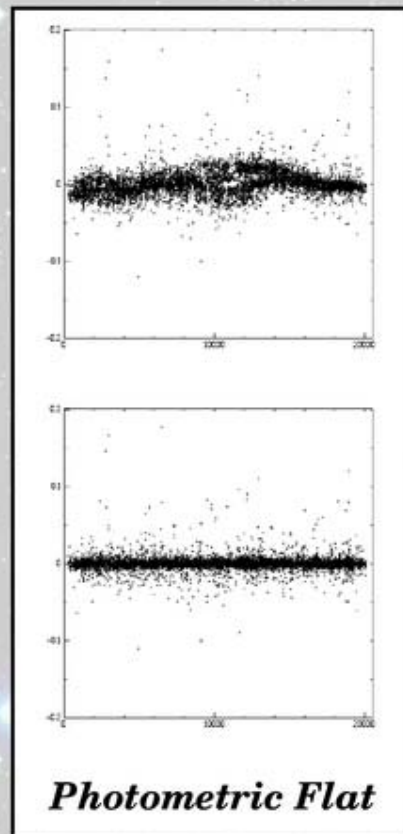
Validated: Deep/SNe = 58%, Wide = 25%, Very Wide = 17%

✓ *Balancing CFHTLS is difficult due to constraints, and is VERY weather dependant*

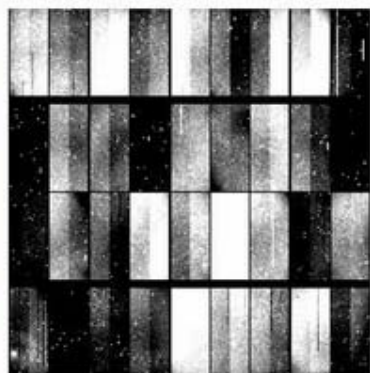
✓ *Effective work by the Steering Group coordinators to establish priorities per run*

Elixir detrending & calibration

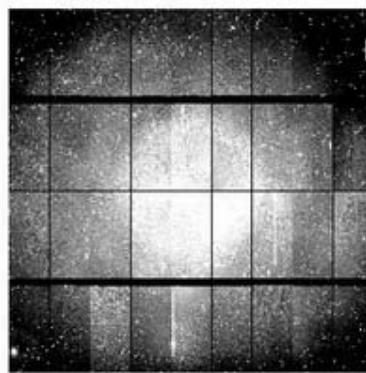
- ✓ *Multi-Extension FITS format exclusively (MEF)*
- ✓ *Data splicing: go from two readouts to a single detector configuration*
- ✓ *Pixels masking: less than 0.2% of the mosaic*
- ✓ *Overscan & bias: gradient in overscan and pixel ringing*
- ✓ *No dark current, hence no correction*
- ✓ *Flat-fielding: twilight flat-fields (has scattered light)*
- ✓ *Photometric superflat: 0.7% photometric flatness across the image*
- ✓ *Fringes: 6% in i' , 15% in z' - Residual < 1% **To be refined!***
- ✓ *Sky background modes **Dismissed!***
- ✓ *Astrometric & photometric calibration **To be refined!***



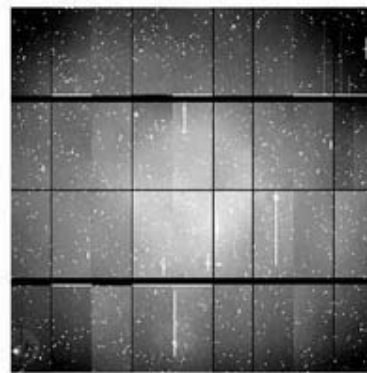
The detrending steps of Elixir (3 mn total):



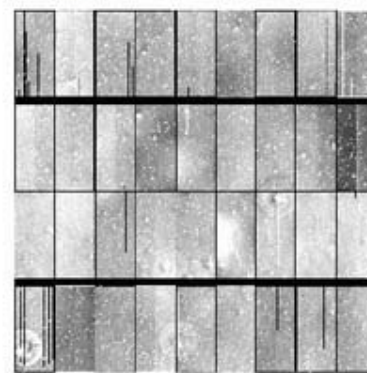
RAW



FLATTEN



DEFRINGE



DEMODES

Data & Computing facilities

✓ *Data so far (Feb. 2005): 42,000 frames archived = 30 Terabytes*

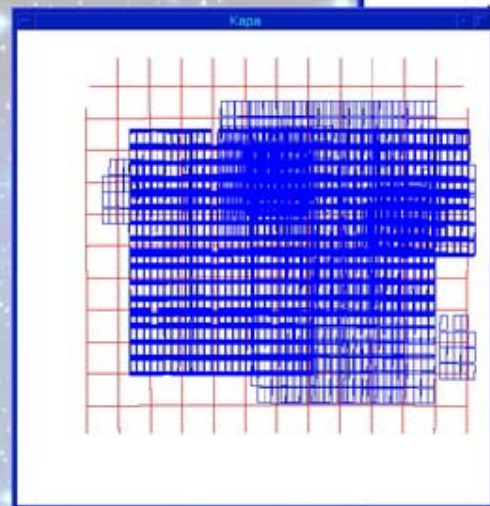
✓ *Hardware:*

- *Archive (DADS):* 12 nodes / 15 Tbytes storage / 20 CPU = 31 GHz
 - *Processing (Elixir):* 13 nodes / 3 Tbytes storage / 20 CPU = 48 GHz
 - *Analysis (Real Time Systems):* 9 nodes / 12 Tbytes storage / 18 CPU = 42 GHz
- Total:* 33 nodes / 30 Tbytes storage / 58 CPU = 1 THz

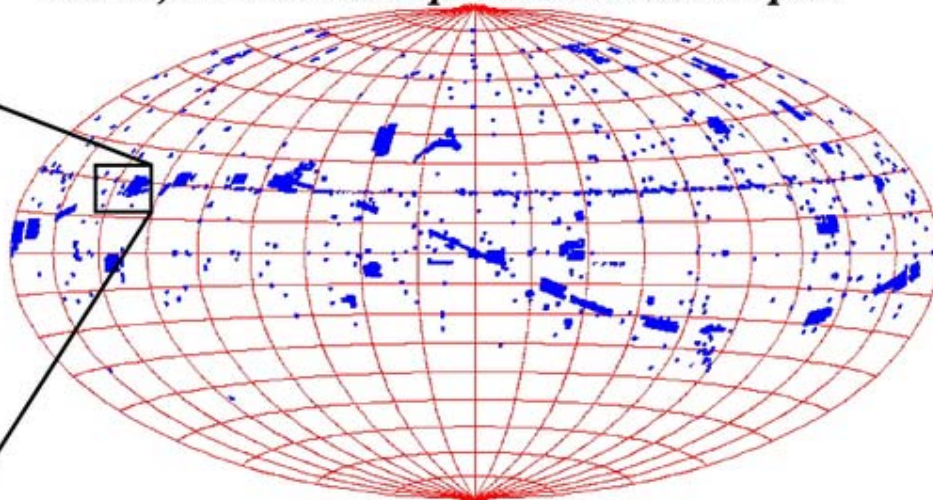
✓ *People: DADS: 1.5 Elixir: 1*

✓ *Mapping the sky:*

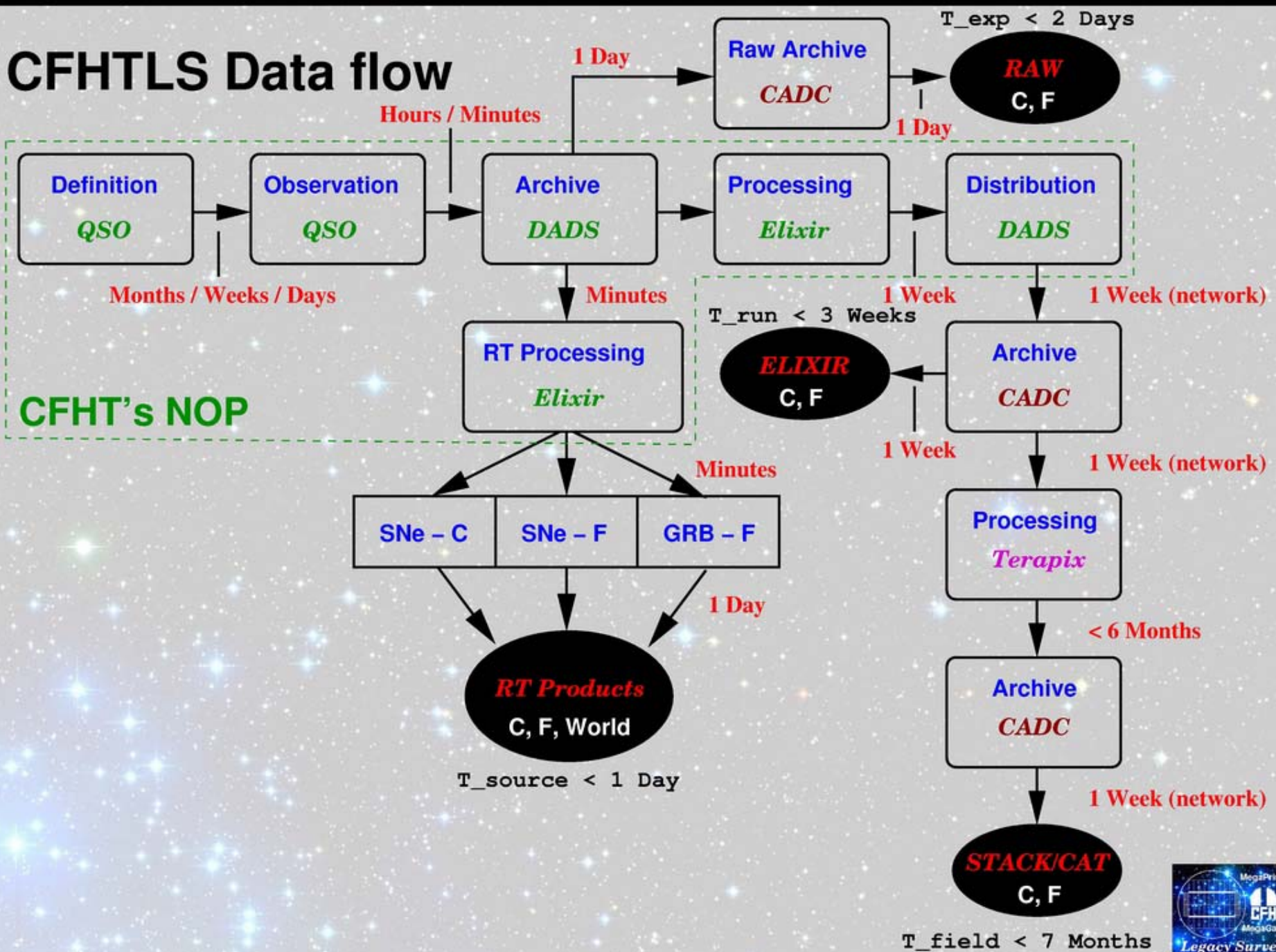
All D1/W1 pointings: ~1600



All 29,000 science exposures statistics plot

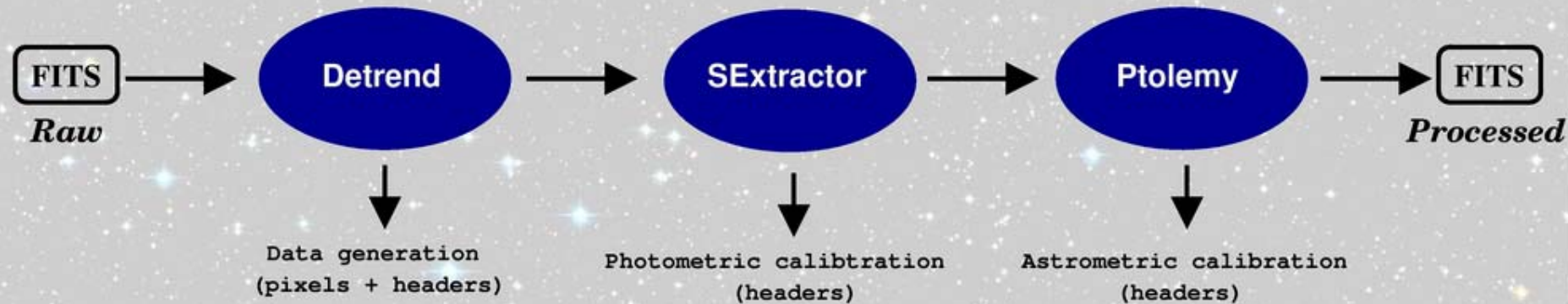


CFHTLS Data flow



Elixir calibration & data products

✓ *Elixir pipeline:*



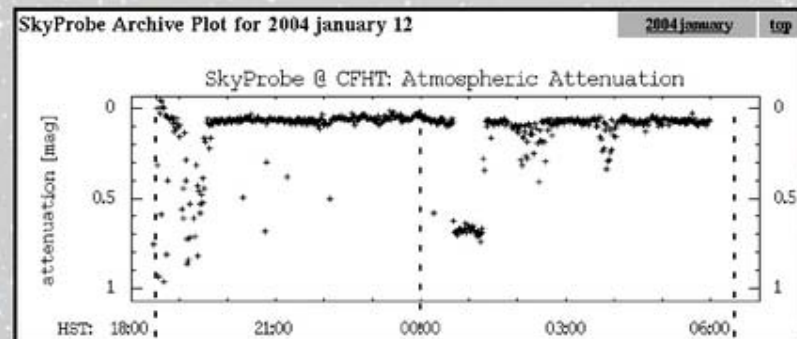
✓ *Astrometry: on a per CCD basis (0.2 arcsec. accuracy)*

✓ *Photometry: one zero point per filter per run based on numerous standard fields observations*

✓ *Master detrend data (Mask, Bias, Flat-fields, Fringe, Modes)*

✓ *Meta-Data tables:*

- *Processed images information*
- *Master detrend information*
- *Standard stars images zero points*
- *Standard star transparency*
- *SkyProbe transparency*
- *QSO comments data*
- *Weather data*
- *Supporting graphics images*



CFHTLS : all Elixir data currently available from June 2003 to today

22 QSO Observing Runs = 6624 validated exposures for 472 hours of light integration

✓ **Deep Survey: 58% (vs target 44%)**

3044 exposures / 271 hours of light integration

D1: 946 exposures / 94 hours integration

D2: 408 exposures / 36 hours integration

D3: 720 exposures / 51 hours integration

D4: 901 exposures / 90 hours integration

✓ **Wide Survey: 25% (vs target 34%)**

1036 exposures / 122 hours of light integration

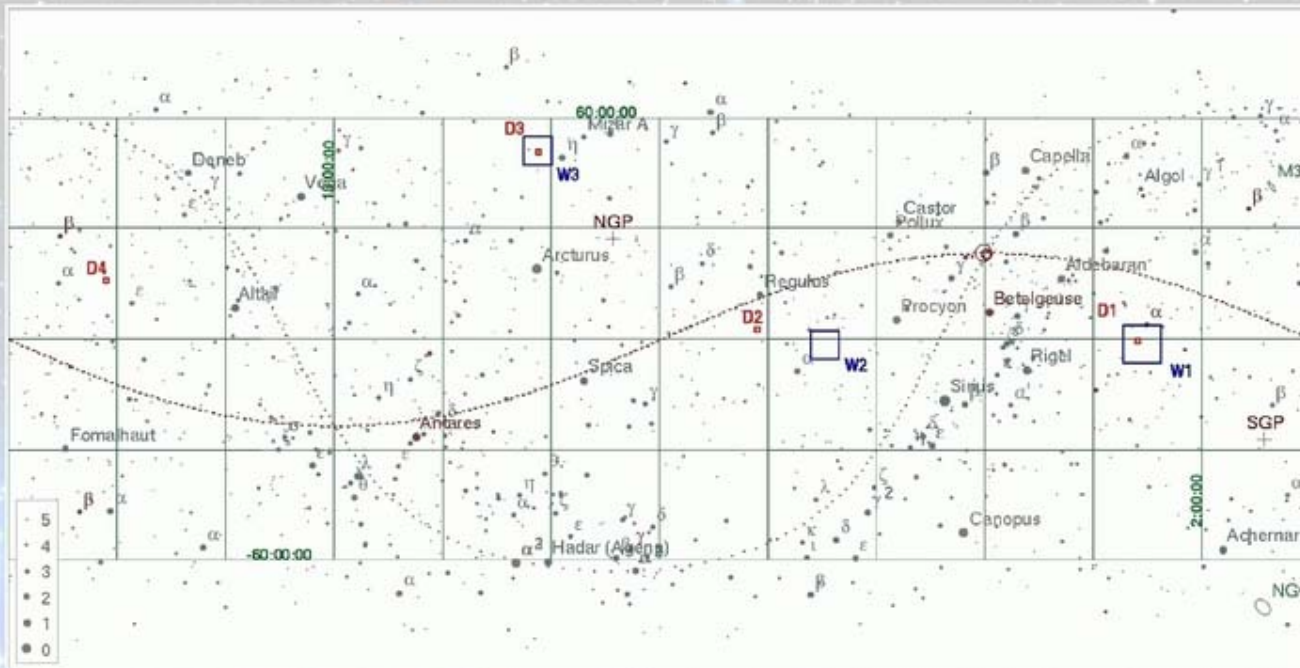
W1: 499 exposures / 75 hours integration

W2: 238 exposures / 23 hours integration

W3: 133 exposures / 17 hours integration

✓ **Very Wide Survey: 17% (vs target 22%)**

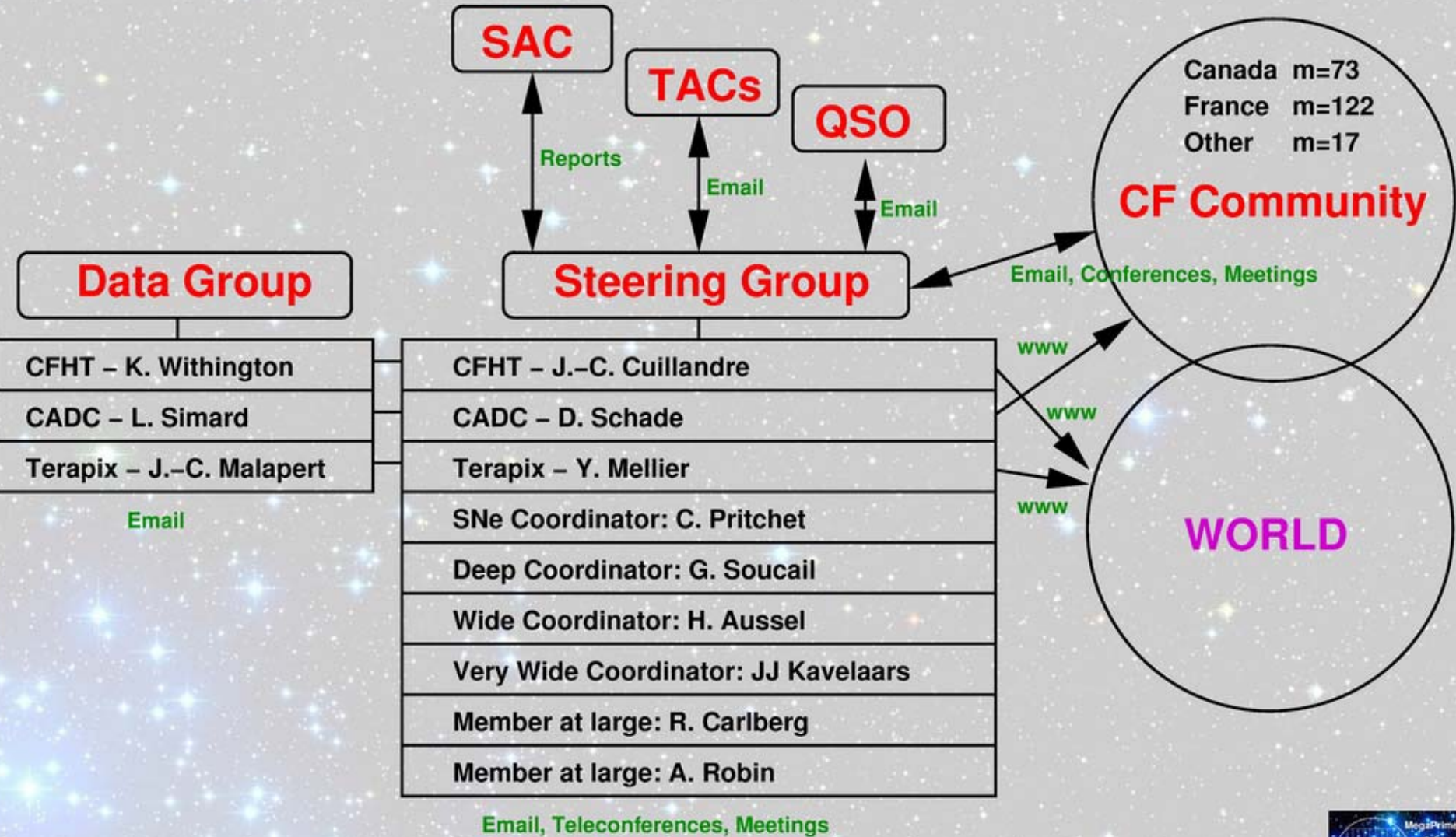
2544 exposures / 79 hours of light integration



**Mean image quality
all Deep exposures**

$u^* = 0.89$ arcsec.
 $g' = 0.89$ arcsec.
 $r' = 0.84$ arcsec.
 $i' = 0.80$ arcsec.
 $z' = 0.76$ arcsec.

The People & Communication channels



Realities of observing:

- ✓ *Bad weather account for *at least* 20% of time lost*
- ✓ *Technical problems accounts range from 20 (04A) to 6 nights (04B) a semester (10% avg)*
- ✓ *Validation process: typically 85%, 03B was only 80% due to poor seeing*

Remaining means to increase the open shutter time per night

- ✓ *Overheads per night = 3 hours (typical length of a night: 9.5 hours)*

● <i>Exposure overheads</i>	<i>70 x 50 sec = 58 mn</i>	<i>Detector limited</i>
● <i>Guide star acquisition</i>	<i>30 x 0.4 mn = 12 mn</i>	<i>Optimized</i>
● <i>Filter change</i>	<i>20 x 1.5 = 30 mn</i>	<i>Difficult to reduce</i>
● <i>Focus</i>	<i>6 x 7 = 42 mn</i>	<i>Soon to be 0 mn (!?)</i>
● <i>Photometric standards</i>	<i>12 x 2 = 24 mn</i>	<i>Could be 0 with tertiary stds.</i>
● <i>Dome rotation</i>	<i>5 x 2 mn = 10 mn</i>	<i>Reduced with less standards</i>

... about 1 hour could still be gained.

*All this contributes for the initial CFHTLS goals not to be achieved
... but things keep getting better each new semester!*

Advertising the CFHTLS in 2004 (mostly by SG members)

The CFHTLS Operation

CFHT: Services provided for the CFHTLS

LSST Symposium	- Sep. 2004
SFZA French Astronomy national meeting	- Jun. 2004
CFHT Users' Meeting	- May. 2004
CFHTLS French National users meeting	- Jan. 2004

CADC: CFHTLS & Archiving

Seminar in Toulouse	- Nov. 2004
LSST Symposium	- Sep. 2004
Cowichan Valley Star Finders	- Jul. 2004
HIA Science Coffee	- Jul. 2004
Astrometry in the Age of Large Telescope	- Jun. 2004
Canadian Astronomical Society	- Jun. 2004
BC Teachers Association	- Feb. 2004
CFHT Users' Meeting	- May. 2004

Terapix: CFHTLS & Data Processing

The Annual Astrowise Meeting	- Dec. 2004
WIRCam workshop on Large Programs	- Nov. 2004
The AVO seminar in Meudon	- Nov. 2004
CFHT 25th Anniversary Press Release	- Sep. 2004
THE ADASS Meeting	- Sep. 2004
Seminars in Marseille, Besancon, Lyon	- Fall 2004
SFZA French Astronomy national meeting	- Jun. 2004
CFHT Users' Meeting	- May. 2004
The AVO meeting in Meudon	- Mar. 2004
General Public conference at Uranoscope	- Feb. 2004
Public Lecture at the College de France	- Feb. 2004
CFHTLS French National users meeting	- Jan. 2004

The CFHTLS Science

Very Wide: CFHTLS & Solar System

Division of Planetary Science Meeting	- Nov. 2004
CFHT Users' Meeting	- May. 2004
skiLS Meeting	- Feb. 2004
Canada France Ecliptic Plane Survey	- Jan. 2004

Wide: CFHTLS & Lensing

Shanghai Summer School in cosmology	- Oct. 2004
Cosmos04 Meeting in Toronto	- Sep. 2004
General Public conference at Bellem	- Aug. 2004
IAU Symp. Impact of lensing on cosmology	- Jul. 2004
Colloquium in Heidelberg	- Jun. 2004

SNLS: Supernovae and Dark Energy with the CFHTLS

SNLS 1st year results - Texas Meeting	- Dec. 2004
ESO seminar	- Nov. 2004
Canadian Undergraduate Physics Conference	- Nov. 2004
Caltech seminar	- Oct. 2004
Cosmos04 Meeting in Toronto	- Sep. 2004
SFZA French Astronomy national meeting	- Jun. 2004
AAS Meeting Denver	- Jun. 2004
Padova Conference	- Jun. 2004
CFHT Users' Meeting	- May. 2004
International Gemini Science Meeting	- May. 2004
Observing Dark Energy (NOAO Workshop)	- Mar. 2004
CIAR Cosmology and Gravitation Meeting	- Mar. 2004
AAS Meeting Atlanta	- Jan. 2004
Rencontres de Moriond	- Jan. 2004



Facts, conclusions and perspectives

- 👍 ✓ *MegaPrime / MegaCam is more and more reliable*
- 👍 ✓ *Image quality has (luckily) improved dramatically*
- 👎 ✓ *Instrument operation overheads too high, need to be further reduced*
- 👍 ✓ *QSO procedure produces quality data in abundance*
- 👍 ✓ *Increased support from the coordinators to the QSO team effort*
- 👎 ✓ *Time constraints affect the overall survey image quality*
- 👍 ✓ *The whole data flow is now in action (CFHT→CADC→Terapix→CADC→Users)*
- 👉 ✓ *Delay in the first Terapix release due to recipes complexity (& Elixir first release in Jan.04)*
- 👍 ✓ *Elixir data available to the community at CADC within 2 to 3 weeks after a run*
- 👍 ✓ *Benefit to Terapix for regular steady releases to the LS community*
- 👍 ✓ *CFHTLS Registered Users download massive amounts of LS data from CADC*
- 👍 ✓ *Science cruising on the real-time components in well organized collaborations*
- 👍 ✓ *Steering Group has made a large effort on communications with the community*
- 👉 ✓ *More interactions (reports) between the SAC, TACs and the SG would benefit the survey*
- ✓ *CFHTLS Workshop to be held in Paris in May 2005 (both C&F communities)*
- ✓ *Work already starting for the preparation of the CFHTLS review in spring 2005*

www.cfht.hawaii.edu/LSW05/

